NAVAL POSTGRADUATE SCHOOL
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THESIS

DEVELOPMENT OF AN IMPROVED ARMY AIRCRAFT SURVIVABILITY EQUIPMENT (ASE) ACQUISITION STRATEGY THROUGH ECONOMIC ANALYSIS AND EMERGING PROCUREMENT PHILOSOPHIES

by

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March 1995

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This thesis examines the previous acquisition strategy of a typical aircraft survivability equipment (ASE) procurement through an economic analysis. It also explores new philosophies to traditional acquisition methods and combines the economic lessons learned to suggest improvements to the current ASE procurement strategy.

The AN/APR-39A(V)1 Radar System Detecting Set (RSDS) was analyzed because it represented, on average, the common approach to acquiring ASE in prior years. After analyzing this system's cost data by using the Learning Rate (LR) Theory, and comparing it to the Should Cost Analysis Team's (SCAT) cost estimation, it appeared that actual costs did not follow the agreed upon 90% LR. A closer examination concluded that a 90% LR was used, but price discrepancies to the LR estimations were caused by an innovative payment scheme.

New approaches to systems acquisition, along with the appropriate use of the LR and payment methods can enhance the acquisition process. This thesis recommends selected new procurement philosophies for an improved ASE strategy.

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This thesis examines the previous acquisition strategy of a typical aircraft survivability equipment (ASE) procurement through an economic analysis. It also explores new philosophies to traditional acquisition methods and combines the economic lessons learned to suggest improvements to the current ASE procurement strategy.

The AN/APR-39A(V)1 Radar System Detecting Set (RSDS) was analyzed because it represented, on average, the common approach to acquiring ASE in prior years. After analyzing this system's cost data by using the Learning Rate (LR) Theory, and comparing it to the Should Cost Analysis Team's (SCAT) cost estimation, it appeared that actual costs did not follow the agreed upon 90% LR. A closer examination concluded that a 90% LR was used, but price discrepancies to the LR estimations were caused by an innovative payment scheme.

New approaches to systems acquisition, along with the appropriate use of the LR and payment methods can enhance the acquisition process. This thesis recommends selected new procurement philosophies for an improved ASE strategy.

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I. INTRODUCTION

The time is right for change. The world, as we knew it as little as six years ago, has undergone tremendous change. We are now experiencing an era that has brought the demise of the status quo. Corporations, systems, manufacturers, and even professional sports, are exerting unprecedented efforts toward continuous improvement to survive in this period of revolutionary change. Businesses or activities that refuse improvement or implement it too slowly, suffer, if not die.

Government is also changing. The President and Vice President have challenged all in Government to "reinvent" it. As a result, we now have "Re-invention Labs." Another catalyst for change is the Vice-President's "National Performance Review." This review proposes to bring common sense and sound business practices into Government operations. It also will replace or modify existing rules and regulations that have little or no value. The result will be to streamline Government processes. This is great news for the military acquisition communities. For several years there have been many studies on "acquisition reform," the 800 Panel being the most noteworthy. Although this study identified many areas for improvement, it did little to actually lessen the burdens of the cumbersome acquisition process. The Clinton Administration, however, is providing the direction and smoothing the path that will lessen the load on the acquisition community. This is the time to be visionary and expend every effort to reassess and reform current acquisition

strategies to capitalize on the loosened regulations and innovative ideas for using the latest technologies and philosophies to develop an improved acquisition strategy that will extend into the 21st Century.

The focus of this thesis is to learn, through an economic analysis of a previous aircraft survivability equipment (ASE) system, how to exploit the opportunities presented in acquisition reform, the changes mentioned above, and emerging Research Development Test & Evaluation (RDT&E) philosophies. Any improvement over the current method of procuring ASE for the United States Army Aviation Fleet of aircraft is certainly desirable. This topic, while focusing solely on ASE procurement, should be on the minds of all Department of Defense (DOD) procurement agencies. This thesis can serve as a model to an innovative and sound approach for all acquisitions. Ideally, this new approach to ASE procurement would foster a wave of continuous acquisition strategy improvements throughout the DOD community.

This study will make use of the Learning Rate (LR) Theory and economic analysis to suggest benefits of the proposed strategies in relation to the current ASE acquisition strategy. The political realities of this period of change include decreasing DOD budgets and decreasing military manpower. The acquisition community must, therefore, assertively and aggressively endeavor to maximize the effectiveness of constrained resources.

A. BACKGROUND

Aircraft Survivability Equipment (ASE) is a crucial component for Army combat rotor-craft. Its effective use by trained pilots and crews greatly contributes to mission accomplishment without loss of lives. Furthermore, it safeguards the U.S. Army's equipment and the American taxpayer's investment. Today's threat is continuously changing and developing and is more uncertain than any ever experienced in U.S. history. American pilots and crews deserve the best ASE and related training to stand ready to defend U.S. interests at any time.

During **OPERATION DESERT SHIELD**, 3100 ASE systems were sent to Southwest Asia (SWA) to either upgrade existing systems or install on aircraft that had no preexisting ASE system. [Ref. 1] The U.S. was fortunate to have adequate time for this to be accomplished. It may not be so lucky in the future. This effort was an accelerated fielding for most of the systems. Accelerated, because deployment was not scheduled until approximately March of 1992. However, because of the imminent war, this monumental task was considered in the best interest of U.S. Forces and the Program Manager (PM) for Aviation Electronics Combat (AEC, formerly ASE) executed this effort by deploying fielding teams and personnel from the ASE office to SWA. Some systems were fielded to sister services that had not previously planned to use them, but because of the impending hostilities, demanded their use. The significance of this effort lies in the realization that in the world we live in **today**, no threat is certain.

Furthermore, we may have no warning of when or where this uncertain threat may strike. Therefore, it is extremely important that our equipment stand ready for hostilities **before** they develop.

B. OBJECTIVE

The primary objective of this thesis is to suggest improvements to the current ASE acquisition strategy. This may be possible by analyzing economic lessons learned from the current strategy and applying that knowledge to emerging RDT&E philosophies, reform initiatives, and innovative procurement strategies. The result could be an improved, efficient, and streamlined procurement process. The ultimate objective, lest we forget, is to ensure that the soldier is properly equipped with ASE prior to hostilities. All efforts to improve the acquisition process support this major objective.

C. RESEARCH QUESTIONS

1. The primary research question to be answered within this thesis is: How can emerging RDT&E philosophies and economic analysis serve to improve the current ASE procurement strategy while remaining flexible to changing threats?

2. The subsidiary research questions to be answered within this thesis are:

a. What has been the dominant ASE procurement strategy in the past?

b. What are the principal considerations that determine how and when ASE will be procured during the life-cycle of the aircraft?

c. What are the economic impacts of 2b, above?

d. How can the use of emerging RDT&E procurement philosophies enhance ASE procurement?

D. SCOPE, LIMITATIONS AND ASSUMPTIONS

1. Scope

The scope of this thesis is focused on the economic lessons learned through the procurement strategy of the AN/APR -39A(V)1 and their impacts on emerging acquisition philosophies. The AN/APR-39A(V)1 Radar Detecting Set (RDS) is an upgraded version of the AN/APR-39(V)1 system. It uses a digital processor, alphanumeric display, and a synthetic voice to provide the pilot warning of radar directed air defense threat systems. This RDS is applicable to all U.S. Army rotor craft. No other system was researched. The reason for this focus is twofold: 1) The AEC procurement team felt this system adequately represents their previous acquisition strategy; and 2) Data on this system was readily available.

2. Limitations

This study is limited by the currency and dynamics of the newly-emerging philosophies of procurement. Data and/or written material is scarce. However, this thesis revealed several documented articles and will exploit them. Other limitations include the dynamics of the current changes affecting the DOD. As I write this thesis, a new change

involving the use of Military Specifications is taking place. The change is to make every use of commercial off-the-shelf (COTS) specifications when possible and use Military Specifications (MILSPECS) only as a last resort. I will use all current changes that fit the scope of this thesis.

3. Assumptions

1. The need for ASE is already established.

2. Aircraft survivability equipment procurement strategy is independent of a particular aircraft (except a new start).

3. The threat is always unknown.

4. The economic analysis used in this thesis can be taught to procurement agencies in the DOD.

E. METHODOLOGY

I will use the current ASE procurement strategy to develop an economic perspective of the AN/APR-39A(V)1 acquisition. After analyzing this information, I will list the economic lessons learned. Based on these lessons learned, I will apply them to the current changes in acquisition streamlining and new innovative thoughts on procurement. The result will be recommendations to improve the current ASE acquisition strategy.

The data obtained on the AN/APR-39A(V)1 was through a personal field study at the AEC headquarters based in St. Louis, Missouri. All other data concerning newly-emerging philosophies on RDT&E were gathered through literature reviews

and/or telephone conversations with authors on those subjects (e.g., Cochrane).

F. ORGANIZATION OF THE THESIS

This thesis is composed of five chapters. Chapter I provides an introduction to the subject of ASE procurement and sets the tone for the dynamic environment of the current Administration as applied to DOD acquisition. Chapter I also contains background information, the thesis objective, research questions, scope, limitations, assumptions, and methodology.

Chapter II describes the previous ASE procurement strategy and contractual approach.

Chapter III contains the economic analysis and lessons learned.

Chapter IV provides the reader with several newly emerging RDT&E procurement philosophies and technologies, with their descriptions. In addition, implications to the industrial base for one of these ideas are mentioned.

Chapter V presents the conclusions and recommendations derived from combining the economic analysis and the emerging procurement ideas. Areas for further research are also presented here.

II. PREVIOUS ACQUISITION STRATEGY

According to the AEC program office, the following acquisition strategy for the AN/APR-39A(V)1 represents, on an average basis, the typical strategy to date for ASE procurement. This is the main reason that this system was selected for this thesis. I would also like to mention that the following strategy was modified from that of the second production buy to fit the first buy, although little in the second buy was changed from the first. This was necessary due to the unavailability of the first production buy strategy. Furthermore, I want to acknowledge that the following strategy was slightly edited from the reference, but unchanged in meaning. Therefore, the strategy follows very closely to Ref. 2.

A. ACQUISITION BACKGROUND & OBJECTIVES

Present technology has made tremendous progress in the aviation community. Particularly, aircraft performance and safety have enjoyed significant improvements in recent years. Ironically, however, these great technological leaps have created a complex atmosphere in the aircraft's cockpit. This busy environment, at times, can become quite tasking on the pilot's workload, sometimes exceeding his/her human capabilities. Add combat situations to this, and the problem becomes worse. The AN/APR-39A(V)1 RSDS should reduce the combat pressures placed on pilot workload by automatically updating, prioritizing, and presenting threat information.

The AN/APR-39A(V)1 RSDS is a radar detecting device that is capable of detecting multiple types of threats, identifying them, and prioritizing them on an indicator located in the aircraft's cockpit. Once the prioritization is made, the information is then audibly communicated to the pilot through the aircraft's intercom system using a synthetic voice. These features significantly reduce the pilot's cockpit workload during stressful periods and enhance aircraft and crew survivability. See Appendix A for a physical description.

This RSDS system updates the previous AN/APR-39(V)1 system by incorporating a digital signaling processor as compared to an analog signal processor. Digitization represents the current wave of military modernization. This RSDS is applicable to the current fleet of U.S. Military rotor-craft.

The Full Scale Development (FSD) phase, currently termed Engineering Manufacturing and Development (EMD), commenced in 1982. The FSD contract was awarded to General Instrument, Dalmo Victor, Belmont, CA, for $9,450,315. Following this contract was a multi-year production contract for $94,919,105 (as of 5 DEC 89), also awarded sole-source to Dalmo Victor.

B. APPLICABLE CONDITIONS

The AN/APR-39A(V)1 RSDS was developed under an Electronic Warfare/Reconnaissance, Surveillance and Target Acquisition (EW/RSTA) Center, Communications-Electronics Command (CECOM) requirement, in response to an intelligence community-identified threat.

According to the FSD contract awarded to Dalmo Victor, the goal was to develop a threat RSDS that would interface with the existing equipment on the aircraft. As a result, the RSDS was to be compatible with the following systems [Ref. 3]:

1. AN/ALQ-136(V)1/5 Countermeasure Jammer. This system is an airborne, automatic, electronic radar jammer designed to defeat or degrade the tracking capability of hostile threat pulse radars. When threat signals are identified and verified, jamming automatically begins and continues until the threat radar signal is no longer detected. The system then ceases jamming, but continues to receive and analyze radar signals. [Ref. 4]

2. AN/AVR - 2 Laser Warning Receiver. The AN/AVR -2 is a passive laser warning system that receives, processes and displays threat information resulting from aircraft illumination by lasers. The threat information is displayed on the AN/APR - 39A(V)1 RSDS indicator in the cockpit. [Ref. 4]

3. Friendly radar systems that reject the display of allied aircraft.

4. Night vision goggles (NVGs) and other NVG and secure lighting requirements.

Because of the successes of the original AN/APR-39, the Government gained high levels of confidence in the contractor and, therefore, expected continued success.

C. COST

1. Design-to-Cost

A Design to Cost (DTC) goal of $20,581 was included in the FSD contract to keep costs low. A Firm-Fixed-Price contract would incentivize the contractor to achieve the lowest possible cost.

2. Application of Should Cost

A Should Cost Analysis (SCA) was conducted for the first production effort and was not planned for the second production. The Government is confident that sufficient competitive sources are available to ensure economic efficiency.

D. PERFORMANCE

The AN/APR-39A(V)1 RSDS can identify the threat by type and warn the pilot of the threat by using a synthetic voice and digital symbols. When a pilot faces a multiple threat environment, the RSDS can detect the most dangerous threat and inform the pilot of such, while prioritizing the remaining threats.

E. RISK

1. Cost

The cost risk is considered moderate. The production hardware cost estimate, based on Design to Unit Production Cost (DTUPC), was closely tracked and monitored during the Engineering Development (ED) program. The DTUPC estimate

appeared to be realistic based on the contractor's proposal.

2. Technical

Since the development of this system began in the early 1970's, the design and proposed manufacturing techniques have stabilized. In fact, the manufacturing techniques to be used in the production are considered state-of-the-art and were demonstrated during the FSD phase. The system was technically mature, so minimal design changes were anticipated. Therefore, the technical risk was considered low.

3. Schedule

With initial productions, schedule trade-offs cannot be written off. Since no prior history on the contractor's delivery performance existed, schedule risk was considered moderate.

The contractor was to begin testing twelve (12) First Article Test (FAT) units approximately eighteen (18) months after the contract award. This would allow time for Government inspection before the initial delivery of production units. Delivery of the initial production units was scheduled to begin twenty-four (24) months after award. The production rate was scheduled to peak at seventy (70) systems per month.

F. ACQUISITION STRATEGY

First, I would like to mention that the AEC PM does not determine the aircraft priorities for the ASE systems that he

is responsible for procuring. The Deputy Chief of Staff for Operations (DCSOPS), Aviation, decides which units will receive a particular ASE system and in what quantities. [Ref. 5] This is important to note because it frees the PM of dealing with possible bitterness among commanders who feel that their unit is more important than others. The PM can, therefore, focus solely on the acquisition aspect and then deliver the systems to the designated users. The economic impacts of the basis of when and who will receive any ASE can often be political. Therefore, these decisions may not always be in the best economic interests of the PM. Nevertheless, this is the system (for now).

1. Program Structure/Approach

The Government managed many facets of the program to include meetings, reports, and on-site visits to monitor the contractor's progress. The level-three drawings and Technical Data Package (TDP) would also be purchased for use in future production efforts. The program also had provisions for a make or buy program and offered Government-Furnished Equipment (GFE) as required.

2. Tailored Features

No significant tailoring was accomplished, but emphasis was placed on value engineering. This was particularly important if a producer other than the developer would receive the production contract. Furthermore, value engineering changes would increase system performance and/or decrease cost.

3. Supportability, Transportability

Interim contractor logistical support was an issue since this was the first production buy. The maintenance concept, however, was consistent with the doctrinal three level approach for Army aircraft. The three levels are: Aviation Unit Maintenance (AVUM), Aviation Intermediate Maintenance (AVIM), and Depot Maintenance (DM). Emphasis at the AVUM level was on removal and replacement of major subassemblies. At the AVIM level, repair of subassemblies for quick return to AVUM was the support goal. Depot level maintenance, therefore, is expected to repair major assemblies beyond the AVIM capabilities.

Spare parts necessary to support the RSDS would be procured in accordance with AR 725-50.

4. Production and Industrial Preparedness

As with any first-time productions, produceability was originally an issue. Additionally, ease of manufacturing and assembly was a major concern to keep costs low and to transfer manufacturing to other contractors if desired. Creating an industrial base in follow-on productions was also addressed and desired.

5. Test and Evaluation

Production line testing and FAT would be required as per the Test and Evaluation Master Plan (TEMP).

6. Computer Resources

By its very nature, the AN/APR-39A(V)1 relies extensively on computer resources. The Communications Electronic Command for Software Engineering (CECOM CSE) was tasked to maintain

the software details and baseline for this RSDS. Any changes desired by the contractor or other producer would require approval from the PM through CECOM. This was necessary to ensure contract validity and to keep the PM informed and in charge. Software documentation and software status reports, as necessary, were also required and maintained by the CECOM CSE.

7. Manpower and Personnel Integration (MANPRINT)

No potential hazards existed before production.

8. Electric Power and Environmental Impact

Electrical, electromagnetic interference, and environmental studies completed during the development phase raised no serious issues.

9. Cost Drivers and Discipline

Continual attention throughout the life-cycle of this system will be asserted to meet the cost goals established early in the development phase. Baseline Cost Estimates (BCE) and DTCs were also initiated during development to set goals for production costs. A DTC goal of $20,581 (constant FY 82 dollars) was specified in the EMD contract. Any cost savings to the Government would be shared with Dalmo Victor as a 90/10 split, respectively. The Government was confident in the cost estimates and had assurances that no major cost drivers existed prior to production.

10. Quality and Risk Management

This RSDS system incorporated mature technologies and represented low technical and cost risks. No milestone III "showstoppers" were anticipated or encountered.

Quality was managed by the Government through several avenues. One way the Government monitored quality was through on-site contractor facility surveillance. This was accomplished by personnel assigned to the Defense Contract Administration Service (DCAS, now DCMC), CECOM Product Assurance, and AEC Program Management Office (PMO). Other methods that measured quality were scheduled program reviews, conferences, and special meetings as required.

11. Vulnerability, Survivability and Endurance

Biological and chemical protection for this system were not designed into this RSDS. The aircraft in which the equipment operates would provide this protection as appropriate. Nuclear and Electromagnetic Pulse (EMP) hardening were not required of the system.

12. Contract Approach

The type of contract anticipated and negotiated was a Firm-Fixed-Price contract. This procurement was for the initial production of the AN/APR-39A(V)1 RSDS. Again, the technology involved in the system was current and no significant technical risks existed. This was the driving factor for using a Firm-Fixed-Price contract. Furthermore, the design baseline was stable.

The benefits of using this type of contract were as follows:

1. Minimum Government risk

2. Reduced Administrative burden for both the contractor and the Government

3. Incentive for the contractor to control costs

4. Incentive for the contractor to maximize efficiency

13. Negotiation Environment

The Government recognized that cost estimation is, at best, an educated guess. The Government, therefore, took the position of offering a fair and reasonable price for the delivered systems.

G. ACQUISITION STRATEGY SUMMARY

Because the AN/APR-39A(V)1 represented mature technology, technical risks were considered low. Contractor performance, however, was a moderate risk because the Government had no historical data on Dalmo Victor. However, because the design baseline was stable, the Government felt confident in using a Firm-Fixed-Price contractual approach. This placed the major cost risk burden on the contractor to produce at the DTC goal. Additionally, multi-year options and data rights were also included in the contract to allow the Government flexibility in future year procurements.

III. ECONOMIC ANALYSIS

The purpose of this economic analysis is to determine, through the use of the LR, the economic lessons learned by the Government in its procurement of the AN/APR-39A(V)1 RSDS. Additionally, the purpose is to apply any lessons learned from this analysis to the new emerging procurement philosophies contained in the next chapter in order to enhance the current ASE acquisition strategy. Before the contract was negotiated and let, several on-site visits and audits were conducted by various Government agencies. Their purpose was to validate the contractor's cost estimates and to ensure that the contractor met certain criteria, for example, adequate accounting procedures and facilities. The visits also measured the contractor's capacity to fulfill the requirements set forth in the contract. I found these audits very beneficial to the Government by reducing unjustified or questionable costs. The analysis that follows was conducted after the first production buy and will serve to illustrate the economic lessons learned from this acquisition.

The methodology that I will use is fourfold. First, I will analyze the cost data for this acquisition and determine, if, in fact, a 90% LR was attained. Second, if a 90% LR was or was not attained, examine possible reasons to explain the difference. Third, I will determine the utility to the Government based on the actual outcome of the purchase. Fourth, I will explain the lessons learned from this analysis. Since the contract was negotiated with an agreed-to LR of 90%,

one would expect the achieved LR to be approximately 90%. Before I begin the analysis, let me briefly explain the learning curve theory.

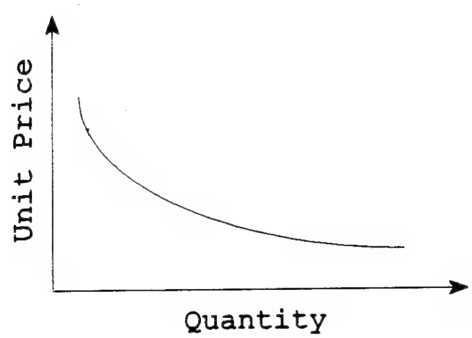
A. LEARNING RATE

A learning rate is not an abstract concept but rather a fairly intuitive one. The meaning of a learning rate is that given a particular repetitive task or function (such as automobile assembly lines or parts component assembly lines) to perform, there is a degree of learning that occurs enabling the performer of such task to become more efficient. As the person continues to perform this particular function, and provided that he or she is not disrupted or there is a change in procedure, he or she can increase his output without added time or maintain a given output with time savings. The efficiency gained through repetitive tasks and processes increases with time because of the habitual familiarity of the task. "The power of the learning curve is such that in some firms unit labor costs have declined 10 to 15% each time output is doubled." [Ref. 6] Learning rate, learning curve, and experience curve all relate to the phenomenon that I have discussed above. An important thing to note about LRs is that the process or function must be left to stabilize. The worker, in addition, must be free from undue job disturbances. Only through repetition, stability, familiarity, and no or little variance, can an LR be achieved and improved upon. If Engineering Change Proposals (ECPs) are required, the LR will normally be disturbed. The significance of the change will

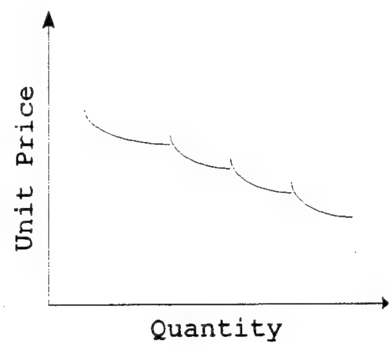
determine how much of the learning process will be lost. If a drastic change is made, then one can expect that the entire achieved LR will be lost. On the other hand, if an ECP is minimal, perhaps only a "bump" in the learning curve will occur and not all of the familiarity of the task will be lost.

Besides a stable process, other factors are important to help create an overall non-disruptive environment. The first thing that comes to mind is personnel. Even in an environment that relies on extensive automation, personnel stability is necessary to achieve a steady LR. Personnel turbulence causes disruptions and negatively impacts the learning curve. In less automated environments, high personnel turnover is more serious due to the loss in continuity. At least in the automated environment there is machinery to provide the desired long term smoothness. Because personnel stability is required to achieve an effective LR, the burden of satisfying the employees must become an objective of management. This is challenging for managers because, as mentioned earlier, the learning rates are commonly associated with repetitive tasks that are extremely difficult to make enjoyable. The working environment is also important. The managers and supervisors must also not have a high turnover ratio. If managers inflict changes (which are common to different management styles) upon the process, disruptions to the LR are likely to occur. However small a change might be, the change to the LR may put a "bump" in the curve. The last thing that comes to mind for achieving an environment conducive to learning curve growth is constant flow. What I mean by constant flow is that

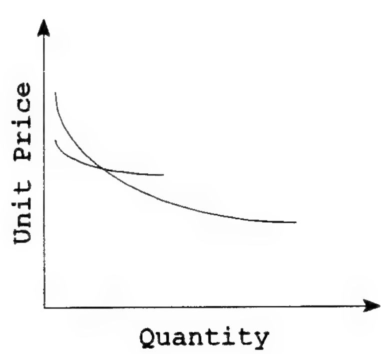
production lines should not produce at a level so high that they have to shut down periodically because they exceed the demand. If an employee works for two weeks and then is "off" for two weeks because production has stopped, the learning curve growth is seriously jeopardized. A constant, steady flow of production ensures the greatest possible LR growth potential. Below are three learning curve examples that illustrate what I have just discussed.



This learning curve represents an ideal situation where a stable environment exists. As the output quantity increases, the unit price decreases at a rate proportional to the learning rate.



At various points along a process, disturbing events occurred which adversely effected the learning rate.



This learning curve represents a major change to the process or complete new job force. In this case all initial learning was lost (smallest line) and a new curve created. Note the new higher initial quantity price (longest line).

1. Learning Rate Formula

The formula for the learning rate is:

$$Y_x = aX^b$$

where,

Y_x = cost of the x^{th} unit

X = x^{th} unit

a = theoretical first unit cost

b = mathematical slope of the learning curve

b = log (LR)/log 2

LR = learning rate

2. Learning Rate Example

If a learning rate of 90% is estimated, and the theoretical first unit cost of an item is $200.00, find the cost of the tenth item.

Solution:

Substitute the given information into the formula provided above.

LR = .9 a = 200 X = 10

Therefore,

$$Y_{(10)} = (200)x(10)^{\log(.9)/\log 2}$$

$$\text{So, } Y_{(10)} = 140.94$$

Conclusion: The expected cost of the tenth unit, given a 90% learning rate, is $140.94.

B. CONTRACTOR COSTS

With a learning rate of 90%, the cost of the 10th unit becomes 70% of the first unit and the cost of the 50th unit becomes 55% of the first unit. Table 1, below, shows how the production cost of a unit decreases with an increased cumulative production for a learning rate of 90%.

Production of i^{th} unit	1	10	20	30	40	50	60	70	80	90	100
Relative cost of i^{th} unit	1	0.7	0.63	0.6	0.57	0.55	0.54	0.52	0.51	0.5	0.5

Table 1
Relative Percentage Cost of Cumulative Production

The total cost of producing Q units, TC(Q), can then be computed as a sum of marginal cost as follows:

$$TC(Q)=\sum(X=1,Q)\,aX^{b} \equiv \{a/(b+1)\}\{Q^{b+1}-1\}$$

and the unit cost of producing Q units, UC(Q), is given by dividing the total cost by the quantity:

$$UC(Q)=TC(Q)/Q = \{a/Q*(b+1)\}\{Q^{b+1}-1\}$$

Table 2, below, shows the effect of 90% learning in terms of the reduction in total cost as well as unit cost when the cost of the initial unit is given as "a." Each production run is assumed to produce 500 units in this illustration. The Table, for example, shows that the first 500 units cost 228a, the second 500 units cost 183a, the third 500 units cost 169a, and the last 500 units cost 160a to produce. The cost reduction of 20%, 6%, and 4% is achieved as more production

runs are made with an increased cumulative production.

Production Run	Quantity Produced	Cumulative Production	Total Cost	Unit Cost	Relative Unit Cost
1	500	500	228a	0.46a	100%
2	500	1000	183a	0.37a	80%
3	500	1500	169a	0.34a	74%
4	500	2000	160a	0.32a	70%

Table 2
Cost of Producing 500 Units

C. ANALYSIS

With this understanding of the Learning Curve, I will examine the outcome of the AN/APR-39A(V)1 first production buy. The learning rate [and DTUPC] considers the following recurring costs: engineering direct labor, engineering overhead, manufacturing direct labor, manufacturing overhead, G&A material, and profit associated with production. [Ref. 3]

Table 3, below, based on [Ref. 3], shows that despite the assumption of a 90% LR, the relative production cost does not seem to decline as expected. In fact, the unit costs for MY1 and MY2 measured in then-year dollars are identical between these production runs. Since the proper comparison of unit cost must be made in constant-year dollar terms, the relative unit costs were computed in MY1-year dollars for these production runs.

First Production Buy	Quantity Produced	Cumulative Production	Payment to the Contractor (then year $)	Cost per Output (then year $)	Relative Unit Cost
MY1	474	474	$17,548,428	$37,022	100%
MY2	587	1,061	$21,731,914	$37,022	100%
OP1	948	2,009	$30,612,822	$32,292	87.2%
OP2	1,174	3,183	$37,786,364	$32,186	86.9%

Table 3

Actual Production and Cost Experience for AN/APR-39A(V)1

Table 4, below, compares the actual relative unit cost and the theoretical relative unit cost using the realized production level for these runs. The fourth column is computed using an average annual inflation rate of 4% to convert the then-year dollar figures to constant-MY1 dollar figures. For this computation, the MY2 production was scheduled to take place nine months after MY1; OP1 production after 15 months, and OP2 after 40 months. [Ref. 3]

First Production Buy	Theoretical Relative Unit Cost	Actual Unit Cost (then year $)	Actual Unit Cost (MY1 $)[2]	Deviation of Actual over Theoretical C4=(C3-C1)/C1
MY1	100%	$37,022 (100%)	$37,022 (100%)	
MY2	80%	$37,022 (100%)	$36,210 (98%)	+ 23
OP1	72%	$32,292 (87.2%)	$30,438 (82%)	+ 15
OP2	66%	$32,186 (86.9%)	$29,094 (79%)	+ 19

Table 4

Comparison of Actual vs. Theoretical Relative Unit Cost

Even after the correction for the escalation, however, the actual relative unit cost seems to be more expensive than the theoretical level. This may be due to the fact, that not all cost components included in the actual costs are subject to the learning phenomenon. For example, the raw material used in production may not be subject to learning as much as the direct labor hours used in production. To adjust for this, the relative unit cost was computed as a function of a percentage subject to learning, β. Let Z be the total initial variable cost, **a** the part subject to learning, and **m** the part not subject to learning. Then we have $Z=a+m$, where $a=\beta Z$, and $m=(1-\beta)Z$. Table 5, below, shows the relative unit cost for varying β values with β=(1, 0.8, 0.6, 0.4, 0.2, 0).

β	1	0.8	0.6	0.4	0.2	0	Actual
MY1	100%	100%	100%	100%	100%	100%	100%
MY2	80%	87%	92%	95%	98%	100%	97%
OP1	72%	82%	88%	93%	97%	100%	82%
OP2	66%	78%	86%	92%	96%	100%	79%

Table 5
Relative Unit Cost as a Function of β

As expected, the more costs are subject to learning, the greater the cost reduction. On the other hand, if nothing were subject to learning (ie., β=0), then the production cost remains the same regardless of the cumulative production as shown in the sixth column. The assumption of β=80% seems to

produce a more consistent relative cost profile to the actual experience. However, even in this case, the MY2 figure diverges by a significant amount. This may be interpreted as either the MY1 payment was too low, or that the MY2 payment was too high, or possibly both. In view of these potential inconsistencies between the actual experience and the theory, the production cost estimates [Ref. 3] made by the contractor, as well as the Government, were closely examined.

Table 6, below, shows that all estimates are very similar to each other in relative terms. Two features are prominent in the table: one is a large cost reduction (more than 50%) from the MY1 production run to the MY2 production run; the second is the relative similarity of the costs for the MY2, OP1 and OP2 production runs.

	C1	C2	C3	C4	C5	
	Contractor Estimate 1	Contractor Estimate 2	Contractor Estimate 3	Government Estimate 1	Government Estimate 2	Avg Est.
MY1	100%	100%	100%	100%	100%	100%
MY2	49%	49%	48%	45%	49%	48%
OP1	50%	49%	49%	49%	49%	49%
OP2	52%	51%	50%	49%	48%	50%

Table 6
Relative Unit Cost Estimates

These characteristics are consistent within an analytical framework when a small proportion of learning, for example β in the 30% range (consistent with Ref. 3), is assumed and an inclusion of fixed cost in MY1 cost figures. With these

adjustments, Table 7, below, shows the relative unit costs.

	C1	C2	C3
	Theoretical Estimate	Average of Contractor and Government Estimates	Actual Experience
MY1	100%	100%	100%
MY2	49%	48%	98%
OP1	49%	49%	82%
OP2	48%	50%	79%

Table 7, Relative Unit Costs with 30% of Costs Subject to Learning

Although the costs estimates made by the contractor and the Government can be reproduced, it seems that the actual "cost" experience, in terms of a 90% LR, does not follow from the LR theory. However, a closer examination and analysis revealed an interesting account of this acquisition. The paragraphs that follow describe this account.

It appears that the unit "costs" used for MY1 and MY2 do not truly reflect the costs of production, but rather they reflect a mutually agreed payment scheme. In fact, the Government and the contractor first negotiated one set of prices (without leveling) based on costs, and then negotiated another final price (with leveling). These prices are reflected below in Table 8.

	Alternative 1		Alternative 2	
	Negotiated Total Price	Negotiated Unit Price	Negotiated Levelized Total Price	Negotiated Levelized Unit Price
MY1	$38,634,324	$81,507	$30,417,997	$64,173
MY2	$21,620,852	$36,833	$29,837,179	$50,830
TOTAL	$60,255,176		$60,255,176	

Table 8
Negotiated Prices

If, in fact, this analysis through an agreed payment scheme is correct, the Government seems to have gained a high degree of utility by levelizing prices at the expense of the contractor. The high degree of utility is explained in the amount of savings the Government obtained. This was possible because the Government was able to defer the payment of $8,216,327 (the difference of $38,634,324 and $30,417,997) for nine months. This savings is illustrated below by computing the present value (PV) of the Government's payment streams. A Government discount rate of 7%, as directed by the Office of Management and Budget (OMB), is used in this calculation.

$$PV(Alt\ 1)=\$38,634,324 + \$21,620,852/(1.07)^{9/12}=\$59,185,419$$

$$PV(Alt\ 2)=\$30,417,997 + \$29,837,179/(1.07)^{9/12}=\$58,778,892$$

Therefore, the Government savings is PV(Alt1) - PV(Alt2), which equals $406,528. Further study of this payment scheme reveals an even better option that enables the contractor to gain, as well.

Another alternative that is a more mutually attractive settlement than Alternative 2 can be constructed. This is because the discount rate applicable to the Government is much

lower than that of the contractor. With a higher discount rate for the contractor, the deferment of the payment into the future is more expensive for him. Therefore, the Government can arrange a less leveling payment scheme that is mutually more satisfactory than Alternative 2. To see this, you will first compute the contractor's present values of the payment using a hypothetical, but certainly reasonable, discount rate of 14%.

$$PV(Alt1)=\$38,634,324 + \$21,620,852/(1.14)^{9/12}=\$58,231,530$$

$$PV(Alt2)=\$30,417,997 + \$29,837,179/(1.14)^{9/12}=\$57,462,507$$

This shows that Alternative 2 is quite costly and the contractor's loss equals PV(Alt1) - PV(Alt2) or \$1,772,912 (under the original scheme). If Alternative 2 is indeed acceptable to the contractor, this alternative does not maximize the gain to the Government. Another plan, Alternative 3, can be constructed to maximize the Government's gain without making the contractor worse off than Alternative 2.

Alternative 3 is constructed by reducing the payment stream in Alternative 1 by \$769,023 in MY1 (this amount is chosen so that the contractor's PV remains the same as in Alternative 2). Similarly, the contractor's gain can be improved without reducing the gain to the Government. Alternative 4 is constructed by reducing the payment stream in Alternative 1 by \$406,528 in MY1. Under Alternative 4, the PV to the Government remains the same as in Alternative 2, however, the PV to the contractor is increased by \$362,496. This is the maximum gain to the contractor without changing

the benefit to the Government from Alternative 2. Because of this, a more attractive payment scheme to **both** parties could be constructed. Alternative 5 illustrates this "win/win" situation. The contractor gains as well as the Government. This can be accomplished by reducing the payment in MY1 by some value between $406,528 to $769,023. For example, Alternative 5 is constructed by reducing MY1 by $500,000. The gain to the Government is $93,472 and the gain to the contractor is $269,023. These Alternatives an PVs are shown in Table 9, below.

	Alternative 2	Alternative 3 Maximum Gain to the Government	Alternative 4 Maximum Gain to the Contractor	Alternative 5 Mutually Attractive Alternative
MY1	$30,417,997	$37,865,301	$38,227,796	$38,134,324
MY2	$29,837,179	$21,620,852	$21,620,852	$21,620,852
Total	$60,255,176	$59,486,153	$59,848,648	$59,755,176
Government PV	$58,778,892	$58,416,396 (+$362,496)	$58,778,892	$58,685,419 (+$93,472)
Contractor PV	$57,462,507	$57,462,507	$57,825,003 (+$362,496)	$57,731,530 (+$269,023)

Table 9
Alternatives and PVs

This economic analysis, through the use of the LR, showed that The Government and the contractor are fairly adept at applying LRs to cost estimation. Exactly how to determine what LR percentage applies to a specific project was not investigated. The analysis revealed that approximately 30% of direct production costs were subject to learning in this ASE

production. This figure may vary from contractor to contractor, however, it may be used as a guideline for Government cost estimating in similar electronic components production or in future ASE acquisitions. Variations to this baseline may be caused by many unknowns, such as labor trainability, steady production cycles, and exact personnel turnover rates. Furthermore, when applying future economic conditions, such as inflation rates and labor and material escalation costs, to out-year price reductions involving the learning rate, the estimation becomes extremely difficult.

Although, initially, there appeared to be some discrepancies in the application of a 90% LR with regard to actual costs, this analysis discovered that a 90% LR was, in fact, used in theory and the actual experience seems to corroborate the rate. However, when looking only at the actual payments over the period of the contract, and not investigating the disparity, there is a temptation to prematurely conclude that the applied LR was substantially less than 90%. Fortunately, this was not true. Quite the opposite was true. It seems that the Government achieved a higher degree of utility than expected. This is evident in the way it was able to negotiate price leveling with the contractor. Not only did the Government meet cost and schedule goals, but it also was able to defer certain payments by levelizing the MY1 and MY2 unit costs. This resulted in cost savings to the Government. Whether or not this was actually planned is not certain. Perhaps a Government funding ceiling was exceeded and the contractor,

eager for a contract, was willing to forgo current cash flows by discounting the first production units, in return for the security of a contract award. Then, in later years, he could increase the price (which causes the appearance of not applying a 90% LR), while staying within Government funding limits. Regardless of the real reason, it seems, however, that the Government could have done even better by negotiating an alternative, such as Alternative 3 discussed in Table 9, that would have allowed the Government an additional $362,496. The contractor's gain would have been unchanged. Nevertheless, it seems certain that careful attention to the pricing scheme or methods of obligating contracts can have significant benefits to the Government as this acquisition showed.

D. LESSONS LEARNED

1. The study and use of Learning Rates in DOD agencies warrants continued training for leverage in contract negotiations and cost estimating.

2. PMs should insist on a definitive price for the theoretical first unit cost.

3. Labor and material escalations should be applied separately from the LR.

4. SCA teams and DCAA audits are extremely beneficial to the Government in examining contractor proposed costs.

5. Only a portion of the production recurring costs are subject to the LR theory (approx. 30% in this case).

6. Because the Government has a lower discount rate than

contractors have, deferment of payments and other pricing schemes should be carefully examined for their final implications.

The next chapter presents new philosophies in procurement, emerging technologies, and acquisition reform, that when mixed with the lessons learned in this chapter, could serve to develop an improved ASE procurement strategy.

IV. EMERGING RDT&E PHILOSOPHIES AND TECHNOLOGIES

After analyzing the previous ASE procurement strategy for the AN/APR-39A(V)1 and extracting the economic lessons learned, I would now like to introduce several new trends in military procurement philosophies. Because of their newness, I do not espouse to be the expert on these trends, but wish to simply convey what I have learned through literature research and conversations with the AEC program office. I would like to point out, however, that these emerging philosophies are unprecedented in that they were virtually unheard of several years ago. But with the newly-created environment of accepted change and acquisition reform, not only are these ideas greatly accepted, but are the first waves of innovativeness. Furthermore, I predict that we will begin to see more creativity within the next year and a half to two years.

After discussing the new philosophies, I will then apply the economic lessons learned from the previous chapter to a selected number of them and determine their potential value to the ASE program office. The economic value is important to discern because resources are continually constrained and highly scrutinized. Any effort to procure military equipment without considering the optimal usage of these limited resources is thwarted. The objective, therefore, is to determine which new philosophy or trend is most economically promising, if at all beneficial. The following paragraphs will discuss selected new trends. Unless otherwise noted, they were obtained from [Ref. 8].

A. NEW PHILOSOPHIES

1. Long Shadows

This philosophy was suggested in 1990 by Ted Gold and Rich Wagner. The central theme behind long shadows is to persuade potential adversaries that the U.S. has the capability to create new systems from concept to production at a fast enough rate so as to render any military aggression futile. Hence, through continuous research and development (and a strong industrial base) a "long shadow" is cast forward. Simply put, this is a deterrent in the form of *potential* U.S. Military might.

An example of long shadow is the Strategic Defense Initiative. [Ref. 8]. This initiative, also known as "Star Wars," was strongly supported and encouraged by former President Ronald Reagan. Through space-based missile systems, the United States would protect its homeland from incoming Intercontinental Ballistic Missiles (ICBMs) by launching missiles from the space-based platforms, thereby destroying the threat missiles in mid-air prior to reaching the U.S. Although highly speculative, this (potential) system may have significantly contributed to the demise of the former Soviet Union. After all, wouldn't we be concerned for our national security if we learned that China possesses this capability? Just the thought of it should wake up ghosts of the "Pearl Harbor Syndrome."

2. Research and Development (R&D) Rollover

This new philosophy was presented by former Secretary of Defense, Les Aspin in 1990. The concept in this new way of procuring military equipment was to maintain programs at advanced development stages while still performing significant R&D in the system. Once production begins, it would incorporate the latest technologies as discovered in continuous R&D efforts.

Two military programs, the Army's new light helicopter, the Reconnaissance Attack Helicopter (RAH-66), Comanche, and the Air Force's Advanced Tactical Fighter (ATF) are examples of this philosophy. An added feature of this procurement philosophy (provided that time is not critical) is that both technologies and production and manufacturing techniques are allowed to mature before the final design specifications are "locked in."

3. Just-in-time-Weapons

Yes, this is similar to the concept of just-in-time inventory. The idea behind this thought is that particular systems or weapons would be fielded upon mobilization. Out of all the new trends or ideas presented here, this one has perhaps the most risks. After all, whose crystal ball would be used to determine the backward timing sequence from the start of the next unknown war?

4. Hover

This concept is similar to that of the Research and Development (R&D) Rollover. Programs would continue in R&D to refine technologies and reduce risks and costs. However,

before obtaining the production decision, there would be three options: "Cancel, hover, or advance to the next phase."

The decision to cancel may be necessary because of a change in user requirements or perhaps a threat failed to materialize, thereby negating the need for a particular weapon or system. The Army's Comanche Program faced this dilemma after the collapse of the former Soviet Union. Congressional pressure almost killed the program in late 1994, but the Army was able to save it. However, the preservation of this program meant dropping it to a "prototype program." Of course, the schedule has slipped considerably.

A decision to "hover" would be based on a factors that still necessitate the weapon or system, but deployment of it is no longer required as scheduled. An example of when a hover decision may be appropriate, is if a perceived threat did, in fact, materialize, but for any given reason, has suffered a major setback in its ability employ its forces. Therefore, a hover decision could benefit a program by buying time for R&D or modeling and simulations.

A decision to proceed to production would be based on an immediate need to defend against a threat that did materialize or has commenced hostilities.

5. Lean Production

This concept was introduced by top Air Force Officials in 1992. Lean Production is a thought to produce only a small amount of a new weapon or system at an efficient rate. By doing this, units that would ultimately be fielded the particular system would become operationally proficient with

it. Therefore, when hostilities commence, the unit does not require additional training with the system and can respond accordingly. This notion, by implication, renders "Just-In-Time Weapons" and "Shelving Technology" (discussed later) inappropriate. Service members must be able to sufficiently train with new equipment to achieve the highest degree of combat effectiveness before they can deploy and fight with a new piece of military hardware/software. Technology and production cannot sit around.

I would also like to add that the Lean Production concept implies that the industrial base (a large factor that cannot be ignored when considering these new philosophies, but is beyond the scope of this thesis) must also be kept "hot" or "wet." In other words, the producibility of a particular weapon or system must be tried and tested before it can be readied for mass production. Technologies that sit on a shelf until needed may not be producible. On the other hand, they may be producible at a much larger price than anticipated or with significant modifications. Producing a "lean" amount would solidify production.

6. Shelving Technology

This is a notion that implies complete development of new technologies and systems, but not producing them until absolutely necessary to counter a particular threat. In a sense, this could be viewed as a "hover" decision. The major difference, however, is that shelving technology implies a more long-term decision to delay production. The decision to hover, on the other hand, suggests a more optimistic view of

entering production sooner. Currently, I am aware of one program that has used this concept of shelving technology: the "M6 Discharger." The M6 Discharger is the future generation smoke-grenade discharger consisting of four launch tubes. [Ref. 9] The decision to "shelve" the program was made on the basis that it was ahead of the development of any future vehicles. Since no regulations existed on how to shelve technology, an intuitive plan was developed and separated into three sections: 1. Technical Data Package (TDP), 2. Logistics Support Analysis, and 3. Interface for the Vehicle.

> The TDP shelving plan contains all information gained during development. Additionally, the TDP also lists suggestions for alternate manufacturing and inspection methods not verified during development.[Ref. 9]

The logistics support analysis plan lists the methods by which logistical data should be incorporated into the host vehicle technical manual (TM). Because the host vehicles do not presently exist, considerable effort was expended to carefully document all logistical and operational concerns learned during the development process. The task of incorporating the M6 Discharger operating and maintenance characteristics will then fall on the developers of the host vehicle. [Ref. 9] Excruciating detail in documentation is, therefore, very important.

The interface data section of the plan included information on electrical cable connections and mounting

hardware. However, such interface materials must be developed for the specific host vehicle. Therefore, future developers must fit the interface elements according to their specific vehicle by relying on data left from the test vehicles. [Ref. 9]

To date, I have heard considerable controversy over the idea of "shelving technology." One of the major issues concerns the industrial base. While those industrial base issues could occupy a thesis in itself, let me briefly discuss a few. One issue is cost. How costly would it be to maintain an industrial base (especially if the new technology requires beyond state-of-the-art equipment and facilities) that is sitting around waiting for permission to begin production? Costs could be astronomical! Now let us assume that the required industrial base exists and has sufficient workflow that cost is no longer an issue. The next possible issue is technological obsolescence. By the time the decision to begin production is made, does the threat possess new capabilities that render the technology obsolete? The threat could have made considerable advances in his own weaponry that call for different countermeasures to defeat it. In this case, technological improvements to the existing "shelved technology" may not be sufficient to counter the threat's advancement. Instead, a totally new approach may be warranted. Other issues include, ramp-up time, tooling, and machinery, to name a few. Consideration of the industrial base is imperative when planning on shelving technology.

B. NEW TECHNOLOGIES

In addition to the new philosophies described above, there are several new technologies that are coming of age and gaining significant appeal as the acquisition realm continues to seek improvement. Without saying, a major goal in acquisition reform is to spend less money while still procuring quality equipment.

In the light of emerging technologies, one stands out as most promising: "virtual prototyping." This concept can be viewed along the same lines as computer-aided design and computer-aided manufacturing (CAD/CAM). The DOD definition of a virtual prototype is:

> A computer-based simulation of a system or subsystem with a degree of functional realism comparable to a physical prototype;
>
> and *virtual prototyping* as:
>
> The process of using a virtual prototype, in lieu of a physical prototype, for test and evaluation of specific characteristics of a candidate design. [Ref. 10]

Virtual prototyping promises to explore new concepts of weapon systems or other military items from the concept exploration phase to the production phase. The Tank and Automotive Command (TACOM) has been experimenting with this concept for several years now. In fact, they have also researched and experimented with virtual manufacturing. In

this regard, simulated factories try to produce the virtual prototype to determine the feasibility of producing the simulated designs. Imagine the resourcefulness of using simulations to explore new visions that can consider almost all facets of a system's life-cycle! Before any physical models are built, simulated models can be extensively designed, redesigned, and even tested. As a result, numerous design changes and product improvements can be effectively incorporated into the system prior to actual material usage. In the acquisition environment, virtual prototyping will cover the following:

> In the context of military procurement, a virtual prototyping environment would address: engineering design concerns of the developer, process concerns of the manufacturer, logistical concerns of the maintainer, and training and doctrinal concerns of the warfighter. [Ref. 10]

This emerging technology possesses unlimited potential. Because of the military drawdown and the decreased military budget, this new concept promises significant cost savings by extensively examining new conceptual military products through computer aided simulation and testing. Traditional costs from the Concept Exploration phase to the EMD phase, therefore, will be reduced enormously.

C. IMPROVED ACQUISITION PROCESS

Coupled with the new philosophies and technologies mentioned above, are other efforts that I also consider as

innovative methods of future procurement. And quite possibly, when tied to the ideas mentioned above, they can achieve astounding results. In the following paragraphs I will discuss two endeavors that aim toward an improved acquisition process. These endeavors are, Open Systems Architecture, and the DOD directive to switch to performance and commercial specifications when military specifications are not necessary.

1. Open Systems Architecture

Open systems architecture comprises a set of mutually accepted industry standards for electrical interfaces. Here are two definitions used when talking about Open Systems:

> ELECTRONICS SYSTEM: The combination of digital/analog, radio frequency, and electro-optical hardware, firmware, and software required to satisfy one or more functions.
>
> OPEN SYSTEM: Design and construction of a system using public or non-proprietary methods and products based on consensus-based standards for interfaces of hardware, software, tools, and architecture. [Ref. 11]

By using open systems, the DOD can procure military equipment without worrying about the proprietary rights of any given defense contractor. This saves money. The architecture of the system would be "open," and, therefore, non-proprietary. More simply, no particular contractor or agency could claim ownership of an "open" standard. The logistical support of the equipment should become less painful, therefore, as many more

suppliers (versus the solitary owner of a non-standard system) would be able to compete for spare parts deliverables. Colonel Thomas E. Reinkober, on 16 September 1994, in the "Open Systems Working Group Outbrief" to Mr. Longuemare, the former acting Under Secretary Of Defense (Acquisition and Technology), described the vision for Open Systems Architecture:

> Facilitate lower life-cycle costs for DOD weapon systems
>
> Infuse DOD requirements into commercial electronics standards development processes
>
> Facilitate weapons systems interoperability for force capability multipliers
>
> Aid technology transfer to US industries for improved international competitiveness [Ref. 11]

This step forward is a force-multiplier in the military acquisition process when combined with the following initiative.

2. Performance-based Standards

Also adding to acquisition reform is the "Blueprint for Change." This is the plan to "decrease reliance, to the maximum extent practicable, on military specifications and standards." [Ref. 12]. "Specifications & Standards - A New Way of Doing Business," dated JUN 1994 was the title of The Secretary of Defense (SECDEF), William J. Perry's Memorandum to top Government Officials. [Ref. 12] In this memorandum, the SECDEF stresses the need to make use of performance and

commercial specifications as the way of meeting the military needs of the future. Here is how Military Specifications and Standards are affected:

> Performance specifications shall be used when purchasing new systems, major modifications, upgrades to current systems, and Non-developmental and Commercial Items, for programs in any acquisition category. If it is not practicable to use a performance specification, a non-Government standard shall be used. Since there will be cases when military specifications are needed to define an exact design solution because there is no acceptable non-governmental standard or because the use of a performance specification or non-Governmental standard is not cost-effective, the use of military specifications and standards is authorized as a last resort, with an appropriate waiver. [Ref. 12]

As I mentioned in the opening chapter, the time is right for change. The way I understand the SECDEFs memo, it makes the change quite clear: use military specifications only as a "last resort." Additionally, I feel that the ability to tailor programs also becomes easier. What I see in Mr. Perry's "intent," is for Government Officials to do business in a sound, efficient, and sensible (emphasis) manner. This is a license, in effect, to all Program Executive Officers (PEOs) and PMs to do the smart thing for their programs and challenge any rule, regulation, or law that doesn't make any sense when applied to their particular program. This is "free reign!" In my opinion, PMs should be feeling euphoria at the amount of freedom they are being given. However, right now there is tremendous skepticism on this new directive.

Many top military and civilian procurement officials feel that most of their military specifications are necessary. I agree with them, partially. For the most part, I feel that time will be the cure for the reluctance to let go of military specifications. Currently, they are a form of security. After all, this is a major change. But read the directive! If all else fails, then military specifications are authorized (with a waiver). It should be taken as an *opportunity* to have the best of both worlds. A possible drawback, on the other hand, according to the AEC PM, COL Oler, "is if the pendulum swings too far to the right." [Ref. 5] What he meant by that statement is that if military specifications are necessary, and the process for acquiring a waiver is extremely slow, then the acquisition process will be slowed as opposed to quickened.

What I have outlined thus far in this chapter are some new innovative ideas and emerging RDT&E philosophies and technologies that I have found in my research for an improved ASE acquisition strategy. Additionally, I discussed two tools, Open Systems Architecture, and the use of performance and commercial specifications, that when combined with the new philosophies, present great potential for improving the acquisition process. Certainly, the information presented here is not a panacea for the cumbersome procurement process, but a starting block for more creativity to break away from the traditional, regulatory-entrenched, acquisition policies. In today's environment of continual process improvement, we must strive for perfecting and changing those processes that

no longer provide added value to the task or process at hand. I believe that the ideas presented in this chapter and the two tools that could help implement them, are only the first of many new creative and innovative improvements to the procurement process. The vision of a better acquisition process has been articulated. In the next few years, innovativeness should flourish and a new process shall be born.

In the next chapter I will discuss possible mixes of emerging philosophies with certain economic lessons learned from Chapter III. By doing so, I will suggest how the current ASE procurement strategy can be improved.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Based on the previous acquisition strategy and economic analysis of the first production AN/APR-39A(V)1, the Government attained a higher degree of utility than expected by attaining cost and schedule goals at a realized savings of $406,528. The Government's price certainty for this product, however, is not clear because Dalmo Victor was justified as a sole-source provider. This purchase was noncompetitive because the processor of the RSDS was proprietary. During the ED phase, Dalmo Victor had developed the processor without Government funding. However, with the first production buy, the Government purchased the TDP which included unlimited rights and level-three (3) drawings. [Ref. 3] This was significant in that deliveries to field units were accelerated to make them available to soldiers serving in Operation Desert Shield/Storm. By not competing the first production buy, this schedule savings was realized. For future production buys, and because Defense resources are dwindling, the Government should allow competition to encourage effective cost management amongst providers, thereby obtaining added flexibility from its waning resources.

The use of a 90% LR was applied to the pricing of the RSDS. However, the cost figures seemed to suggest less than a 90% LR. Through careful analysis, an ingenious use of price leveling and deferment of payment allowed the Government to realize a savings of nearly half a million dollars. While

this amount may seem trivial, think of the added savings throughout the DOD if other programs could do the same thing. The savings should increase substantially. On the other hand, there is also the opposite to consider. Look at the savings that are not being taken advantage of with price and payment schemes such as this system achieved.

This was a major lesson learned and such pricing strategies warrant more study and consideration in DOD acquisitions.

B. RECOMMENDATIONS

The economic lessons learned from the AN/APR-39A(V)1 acquisition and the emerging procurement philosophies and technologies show significant promise that can serve as a basis to develop an improved ASE procurement strategy. Large savings can be realized, for example, by combining the "Hover" philosophy and virtual prototyping. Before anything is built, computer modeling and simulation can create it in cyberspace. Many changes can be made to the design and then testing can be accomplished in a matter of hours. Think of the accumulated savings on materials, labor, and tooling, without even turning a wrench. Furthermore, this process enables the production design to become stabilized. This is significant because with a stable design, maximum benefit in cost estimation can be achieved by using a stable LR. Minimal, if any, ECPs would be required and the Government could gain leverage against contractors in estimating the contract cost. Other mixes and recommendations are described below.

While the above recommendation can have a significant impact in the design phase, its benefits also reach into the production phase. While in this phase, considerable efforts could be made in exploring designs that take advantage of open systems. In fact, I would recommend proprietary systems only as a last resort. Open systems architecture would reduce total life-cycle costs because international standards are less expensive than proprietary standards. Logistical concerns would also be reduced because more producers can compete to build spare parts without infringing on proprietary rights. Add to this approach performance-based specifications, and some time for contractors to realize this freedom, and the results should be impressive. I believe that within the next decade, defense industries will commit to establishing commercial standards that are not military specifications, but will suit military needs without the costs inherent in military specifications.

From this analysis, I believe that an improved ASE acquisition strategy is possible if the ideas mentioned above are explored for their value added to the current strategy. While other possibilities were addressed in Chapter IV, they either do not promise as much potential as those mentioned here, or are already being used. Incorporating these new methods and a streamlined process promise to provide higher quality weapons and systems to the soldier than those delivered through the traditional methods. Additionally, the recommendations mentioned above would be moderately adaptable to changing threats. This is possible because systems can

remain in the design phase longer (virtual prototyping and "hover"), and as open systems become the norm, changes to the design would not require a revamping of electrical interfaces. Revolutionary change to old procurement strategies and methods is now possible. The soldier in the field deserves the best equipment that the acquisition system can provide. It is essential that every effort be made to provide this service by exploiting the current opportunities.

C. RECOMMENDATIONS EXCLUSIVE OF STRATEGY

1. Along with the move to performance-based specifications, insist on an open systems architecture.

2. Should-Cost Analysis Teams and DCAA audits are an effective means to reduce questionable costs.

3. Ensure that material and labor escalation costs are kept separate from the use of the LR.

4. Consider new methods for incentivizing contractor performance by varying payment schemes.

5. As limited defense funds grow increasingly unstable, consider purchasing data rights as an option. In the event that the program is canceled, less money is lost.

6. Expect the unit quantities within deliveries to increase with time if a contractor promises learning.

D. AREAS FOR FURTHER RESEARCH

1. The impact on the industrial base if "shelving technology" becomes a viable alternative to traditional procurement.

2. How long can a system "hover" without detriment or undue increased costs to the Government?

3. The effect of TDPs as the procurement profession moves to open systems. Should data rights still be purchased?

4. Cost estimating through the use of LRs.

5. Pricing strategies that are mutually beneficial to both the Government and the contractor.

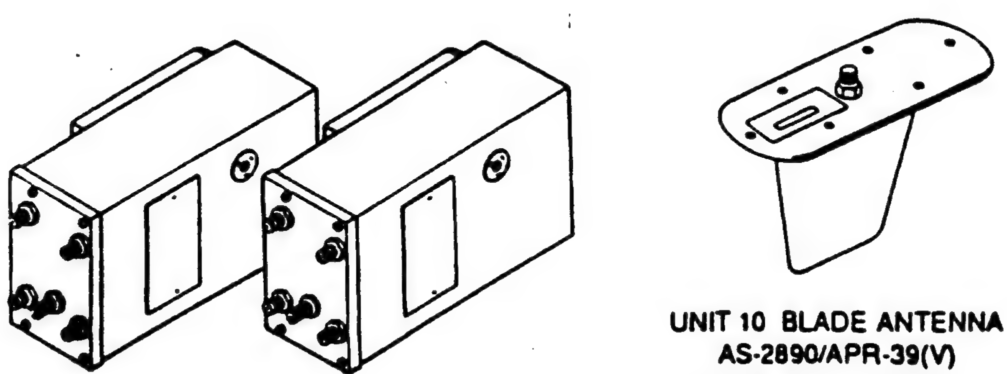
APPENDIX A. AN/APR-39A(V)1 PHYSICAL DESCRIPTION

GENERAL

The AN/APR-39A(V)1 is an upgrade to the AN/APR-39(V)1. Warnings of radar directed systems are presented to the pilot via a digital processor, alphanumeric display, and synthetic voice.

CHARACTERISTICS

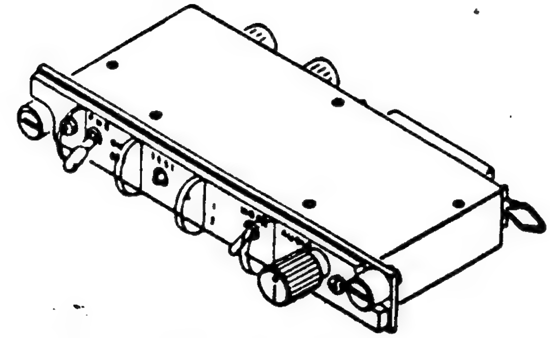
This system is compatible with the aircraft that use the AN/APR-39(V)1. Slight modifications to the existing aircraft wiring are necessary on some aircraft. Each of the ten components that make up the system (pictured below and on the following page) is independently replaceable. The system weight totals 15.5 lbs. This system is applicable to the following aircraft: AH-1F (COBRA), AH-64/D (APACHE), CH-47D and MH-47E (CHINOOK), UH-60Q (BLACKHAWK, MEDEVAC), MH-60K (BLACKHAWK, VARIANT), AND OH-58C&D (KIOWA and KIOWA WARRIOR).



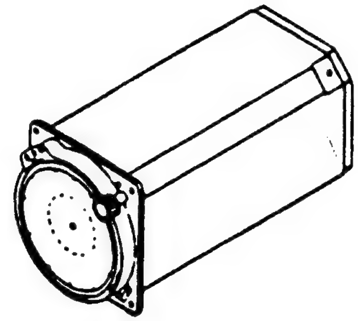
UNIT 10 BLADE ANTENNA
AS-2890/APR-39(V)
(01-026-3927)

UNIT 5 RADAR RECEIVER
R-2218/APR-39(V)
(01-204-8266)

UNIT 4 RADAR RECEIVER
R-2218/APR-39(V)
(01-204-8266)

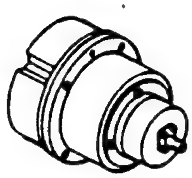


UNIT 1 DETECTING SET CONTROL
C-11308/APR-39A(V)
(01-205-0658)

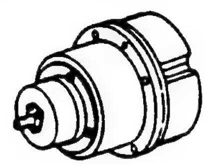


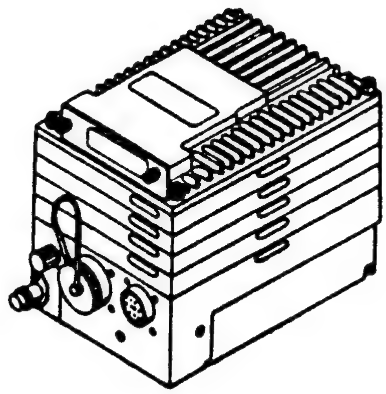
UNIT 2 RADAR SIGNAL INDICATOR
IP-1150A/APR-39(V)
(01-110-2230)

UNIT 9 ANTENNA-DETECTOR
AS-3548/APR-39(V)
(01-204-8211)

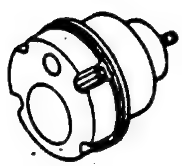


UNIT 6 ANTENNA-DETECTOR
AS-3549/APR-39(V)
(01-204-8210)

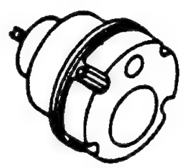




UNIT 3 DIGITAL PROCESSOR
CP-1597/APR-39A(V)
(01-259-0807)



UNIT 8 ANTENNA-DETECTOR
AS-3549/APR-39(V)
(01-204-8210)



UNIT 7 ANTENNA-DETECTOR
AS-3548/APR-39(V)
(01-204-8211)

APPENDIX B. COST DATA

A. ACTUAL COSTS

(The following is a retype of an original memo [Ref. 7] for clarity purposes. It was also reduced to 10 pitch to fit the page.)

SFAE-AV-AEC-B (HOOVER) 29 SEP 94

AN/APR-39A(V)1 RADAR SIGNAL DETECTING SET(ALSO KNOWN AS RADAR WARNING RECEIVER)

FIRST PRODUCTION CONTRACT DAB07-86-C-S031, DATED 24 SEP 86, WITH GENERAL INSTRUMENT CORPORATION (NOW KNOWN AS LITTON SYSTEMS INC., APPLIED TECHNOLOGY DIVISION, SAN JOSE, CA.)

CONTRACT TYPE: FIRM-FIXED-PRICE, TWO MULTI-YEARS, WITH TWO MULTI-YEAR OPTIONS

FIRST MULTI-YEAR AWARD-30 SEP 86-QTY 474-UNIT PRICE $37,022 - FY86

SECOND MULTI-YEAR AWARD-19 DEC 86-QTY 587-UNIT PRICE $37,022 - FY87

FIRST MULTI-YEAR OPTION AWARD-23 JAN 87-QTY 112-UNIT PRICE $34,663 -FY87

FIRST MULTI-YEAR OPTION AWARD-16 JUN 88-QTY 765-UNIT PRICE $31,467 - FY88

FIRST MULTI-YEAR OPTION AWARD-22 SEP 89-QTY 71-UNIT PRICE $37,441 - FY89

SECOND MULTI-YEAR OPTION AWARD-18 SEP 90-QTY 1174-UNIT PRICE $32,186 - FY90

SECOND MULTI-YEAR OPTION AWARD-30 NOV 90-QTY 121-UNIT PRICE $32,186 - FY91

OPTION YEAR QTYS WERE DOUBLED THE FIRST AND SECOND MULTI-YEAR BUYS. 30 NOV 90 OPTION AWARD WAS OBTAINED BY THE PM REQUESTING AN EXTENSION TO THE CONTRACT.

THE CURRENT TOTAL SUM OF THIS CONTRACT IS $180,447,555.00. THIS TOTAL INCLUDES THE COST OF SM-674A SIMULATORS, MX-9848A BENCH TEST SETS, NUMEROUS ENGINEERING CHANGE PROPOSALS, AND SOME FMS DOLLARS. THIS CONTRACT REMAINS OPEN UNTIL JUNE 1997.

THERE ARE TWO COMPONENTS THAT ARE FURNISHED AS GFE TO COMPLETE THIS SYSTEM. THE IP-1150A INDICATOR AND THE ANTENNA BLADE. THESE COSTS ARE NOT INCLUDED IN THE ABOVE PRICES. THE IP-1150A WAS PROCURED ON SEPARATE CONTRACTS AND THE ANTENNA BLADE WAS REQUISITIONED THROUGH THE DEFENSE LOGISTICS AGENCY.

B. NEGOTIATED OPTION COSTS

The following is a representation of option year costs under three alternatives. Each alternative considers a different mix of future economic indicators as applied to labor and material escalations. [Ref. 3]

AN/APR-39A(V)1 SYSTEM - MULTI-YEAR OPTION1

	ALTERNATE 1		ALTERNATE 2		ALTERNATE 3	
QUANTITY	UNIT	TOTAL	UNIT	TOTAL	UNIT	TOTAL
920	30444	28008628	30708	28251719	31301	28797296
921	30443	28038224	30707	28281580	31300	28817749
922	30442	28067820	30707	28311440	31300	28858202
923	30441	28097415	30706	28341300	31299	28888655
924	30440	28127010	30705	28371159	31298	28919107
925	30440	28156605	30704	28401018	31297	28949559
926	30439	28186199	30703	28430876	31296	28980011
927	30438	28215793	30702	28460735	31295	29010462
928	30437	28245387	30701	28490592	31294	29040913
929	30436	28274980	30700	28520450	31293	29071363
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
948	30419	28837180	30683	29087670	31276	29649851

MULTI-YEAR OPTION 2

1165	31332	36501463	31694	36923853	32190	37501322
1166	31331	36532268	31694	36955021	32190	37532985
1167	31331	36563073	31693	36986188	32189	37564648
1168	31330	36593878	31693	37017355	32189	37596311
1169	31330	36624682	31692	37048522	32188	37627973
1170	31329	36655486	31692	37079689	32188	37659636
1171	31329	36686290	31692	37110855	32187	37691298
1172	31329	36717094	31691	37142021	32187	37722960
1173	31328	36747897	31691	37173187	32186	37754621
1174	31328	36778700	31690	37204353	32186	37786283

APPENDIX C. ACRONYMS

AEC	Aviation Electronic Combat
AN/AVR-2	Passive Laser Warning System
AN/ALQ-136(V)1	Electronic Radar Jammer
AN/APR-39A(V)1	Radar Detecting Set
ASE	Aircraft Survivability Equipment
ATF	Advanced Tactical Fighter
AVIM	Aviation Intermediate Maintenance
AVUM	Aviation Unit Maintenance
BCE	Baseline Cost Estimates
CAD/CAM	Computer-Aided Design/Computer-Aided Manufacturing
CECOM	Communications Electronic Command
COTS	Commercial Off-The-Shelf
CSE	Computer Software Engineer
DCAS	Defense Contract Administration Service
DCMC	Defense Contract Management Command
DCSOPS	Deputy Chief of Staff for Operations
DM	Depot Maintenance
DOD	Department of Defense
DTC	Design to Cost
DTUPC	Design to Unit Production Cost
ECP	Engineering Change Proposal
ED	Engineering Development
EMD	Engineering Manufacturing and Development
EMP	Electromagnetic Pulse
EW/RSTA	Electronic Warfare/Reconnaissance, Surveillance and Target Acquisition

FAT	First Article Test
FSD	Full Scale Development
GFE	Government Furnished Equipment
LR	Learning Rate
MANPRINT	Manpower and Personnel Integration
MILSPECS	Military Specifications
MY1	Multi-year 1
MY2	Multi-year 2
NVG	Night Vision Goggles
OMB	Office of Management and Budget
PEO	Program Executive Officer
PM	Program Manager
PMO	Program Management Office
PV	Present Value
R&D	Research and Development
RAH-66	Reconnaissance and Attack Helicopter ("Comanche")
RDS	Radar Detecting Set
RDT&E	Research, Development, Test and Evaluation
RSDS	Radar Signal Detecting Set
SCA	Should Cost Analysis
SECDEF	Secretary of Defense
SWA	Southwest Asia
TACOM	Tank and Automotive Command
TDP	Technical Data Package
TEMP	Test and Evaluation Master Plan
TM	Technical Manual

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